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THE VIRGINIA JOURNAL OF SCIENCE

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The Science of Colloids

ERNST A. HAUSER

Massachusetts Institute of Technology

Sir William Dampier Whetham made the following statement in 1932:

> "To the scholar, the man of science sometimes seems to be busy about little facts and trivial problems in an entirely superficial way. On the other hand, to the philosopher or the man of science, if they ignore the underlying verities and look only to little interpretations, it seems that, as Hume said, 'Popular theology has a positive appetite for absurdity.' . . . Here again the historical method enables us to get beneath surface trivialities, see the deepest secrets of nature that may lie hid in the movement of the needle of a galvanometer or the marking on a butterfly's wing and trace the groping of man's soul . . . And so physical science continually widens our knowledge of the phenomena of the natural world and of the relations between the concepts, final or proximate, that we use to interpret the phenomena . . . As Newton said, 'The business of natural philosophy is to argue from phenomena . . . and to deduce causes from effects till we come to the very first cause, which certainly is not mechanical'."

Exactly twenty years before Sir Whetham made his statement, the German scientist, Wilhelm Ostwald, made the following remarks:

> "Natural science and natural philosophy are not two fields which oppose each other, but they belong together just as two paths which lead to the same goal. This goal is: The mastery of nature by the human being. This is accomplished by the various natural sciences, all of which collate the actual circumstances between natural phenomena and attempt to discover if and to what extent they depend on each other. This is done in order to be able to predict one phenomenon from what is known of another with more or less accuracy. Natural philosophy joins in such attempts, but only in a more general way . . . Every representation of science has its natural philosophical component. In specific articles in which scientists report their progress, the natural philosophical components are generally present in the form of assumptions, of sentences which are not discussed, frequently not even referred to specifically, but on whose acceptance the most important deductions are based. In all such cases these important sentences can never be found in the right places. If they are contained in the introduction of the textbook they are of little value because the facts they actually should summarize are developed only later in the book. If they are contained in

Editor's Note: We are pleased to present this invited article by Mr. Ernst A. Hauser, Professor of Colloid Chemistry at the Massachusetts Institute of Technology, and Visiting Professor of Colloid Chemistry at the Worcester Polytechnic Institute in Worcester, Mass.

the summary at the end they are too late because they have been previously used already in many instances without, however, referring to their general importance. The best thing to do is to permit generalization only in such measure as the given individual facts call for and justify.

"Therefore any education in natural sciences is interpenetrated by natural philosophy. Just as one can obtain a survey over a complicated structure, as for example the confusion of streets in a large city, only if one has all information about the individual streets and also knows the relation of one to another after having studied a general city plan, it is advisable when studying a special branch of science to look at the general plan so that one does not become confused whenever one's path leads through an unfamiliar section."

Michael Faraday's life history is one of the most striking examples of Ostwald's and Whetham's reasoning. When Faraday reached the age of thirteen he had to start earning his own living. In 1805 he became an apprentice bookbinder, and although he did not have an opportunity to attend an advanced school, he loved to read the scientific books which he had to bind. Occasionally his superior gave him permission to attend some evening lectures on science, and in 1812 a customer of the shop who had heard of Faraday's interest in science gave him a ticket for a course of four lectures on chemistry offered by Humphry Davy. On March 1, 1813, Faraday entered the employment of the Royal Institution as Davy's assistant. Shortly thereafter Faraday accompanied Davy on an extended trip to Europe where he became acquainted with several leaders in the field of electrical problems. During the years 1831 to 1840 Faraday devoted most of his time to research in electro-magnetic problems. At the age of forty he laid the foundation for what we today term a transformer and for what we consider as a modern dynamo.

On February 5, 1857, Michael Faraday presented the Bakerian Lecture. He had chosen as his title, "Experimental Relations of Gold (and Other Metals) to Light." In this lecture he made the following statements:

"Agents competent to reduce gold from its solution are very numerous, and may be applied in many different ways, leaving it either in films, or in an excessively subdivided condition. Phosphorus is a very favourable agent when the latter object is in view. If a piece of this substance be placed under the surface of a moderately strong solution of chloride of gold, the reduced metal adheres to the phosphorus as a granular crystalline crust. If the solution be weak and the phosphorus clean, part of the gold is reduced in exceedingly fine particles, which becoming diffused, produce a beautiful ruby fluid. . . .

"Fluids thus prepared may differ much in appearance. Those from the basins, or from the stronger solutions of gold, are often evidently turbid, looking brown or violet in different lights. Those prepared with weaker solutions and in bottles, are frequently more amethystine or ruby in colour and apparently clear. The latter, when in their finest state, often remain unchanged

for many months, and have all the appearance of solutions. But they never are such, containing in fact no dissolved, but only diffused gold. The particles are easily rendered evident, by gathering the rays of the sun (or a lamp) into a cone by a lens, and sending the part of the cone near the focus into the fluid: the cone becomes visible, and though the illuminated particles cannot be distinguished because of their minuteness, yet the light they reflect is golden in character, and seen to be abundant in proportion to the quantity of solid gold present. Portions of fluid so dilute as to show no trace of gold, by colour or appearance, can have the presence of the diffused solid particles rendered evident by the sun in this way."

Michael Faraday offered further evidence for his conclusion, but unfortunately his point of view was not accepted.

It cannot be denied that Faraday, on the basis of pure logical reasoning, made most important contributions to the science of colloids. It was Thomas Graham, however, who laid the scientific foundation of colloid chemistry. Graham published two particular papers, the first of which must be regarded as the actual cornerstone of systematic colloidal research. He paid no attention to the argument which started with Faraday's disclosure because he was primarily interested in studying the diffusive power of liquids and in establishing differences comparable to various degrees of volatility. The respective passage of Graham's paper reads as follows:

"The comparatively fixed class, as regards diffusion, is represented by a different order of chemical substances, marked out by the absence of the power to crystallize, which are slow in the extreme. Among the latter are hydrated silicic acid, hydrated alumina and other metallic peroxides of the aluminous class, when they exist in the soluble form; with starch, dextrin, and the gums, caramel, tannin, albumen, gelatin, vegetable and animal extractive matters. Low diffusibility is not the only property which the bodies last enumerated possess in common. They are distinguished by the gelatinous character of their hydrates. Although often largely soluble in water, they are held in solution by a most feeble force. They appear singularly inert in the capacity of the acids and bases, and in all the ordinary chemical relations. But, on the other hand, their peculiar physical aggregation with the chemical indifference referred to appears to be required in substances that can intervene in the organic processes of life. The plastic elements of the animal body are found in this class. As gelatine appears to be its type, it is proposed to designate substances of the class as 'colloids,' and to speak of their peculiar form of aggregation as the 'colloidal condition of matter.' Opposed to the colloidal is the crystalline condition. Substances affecting the latter form will be classed as 'crystalloids'."

Graham also pointed out that a dominating quality of colloids is the tendency of their particles to adhere, aggregate and contract. If it is

borne in mind that the colloidal state of matter is the result of a peculiar attraction and aggregation of molecules, it is not surprising that colloidal characteristics spread on both sides into the liquid and solid condition. Unfortunately, however, Graham did not continue his research and paid no attention to the possibility that gold sols might exist.

About thirty years after Graham had published his basic contribution a few scientists claimed that colloids are true solutions and that only a few insoluble particles are present. In contrast thereto, a few other scientists, particularly Wilhelm Ostwald, claimed that this statement was not correct but that one is actually dealing with matter in an extremely fine degree of dispersion. Richard Zsigmondy was one of those who originally had voiced serious objections to Faraday's statements. He claimed that the so-called "heterogeneous" theory of colloidal solutions was incorrect. Zsigmondy, however, decided to try to prove or disprove Faraday's hypothesis. He figured that if he could place a solution of colloidal gold sol on the microscope table and then focus the sunlight at a right angle onto the container in which he had placed the sol, he might be able to discover whether or not such particles actually existed. In the publication in which he discussed his experiment and in which he refuted the solution theory, he stated:

> "How entirely erroneous was my idea! A swarm of dancing gnats in a sunbeam will give one an idea of the motion of the gold particles in the solution. This motion gives an indication of the continuous mixing up of the fluid, and it lasts hours, weeks, months, and if the fluid is stable, even years."

Immediately thereafter Zsigmondy contacted H. Siedentopf, who was the scientific adviser of the Carl Zeiss optical works in Jena, and they developed what still today is known as the "slit ultramicroscope."

Not only did this invention increase the range of visibility from about 500 millimicrons down to dimensions of only a few millimicrons, but it also established the following facts of general importance to natural science:

> 1. That colloidal solutions must be classified as heterogeneous systems insofar as their noncoherent particles, microscopically invisible but detectable in the ultramicroscope, are suspended in a medium. The size of these particles is below 10^{-4} cm. and above 10^{-7} cm.
>
> 2. That since the Brownian motion of the ultramicroscopically visible particles can be considered as a thermal movement following the same laws as deductible from the kinetic-gas theory, ultramicroscopy must be accepted as the first actual experimental proof that the kinetic-gas theory with all its conclusions stands to fact.
>
> 3. That experimental proof could be offered for the energy-distribution law of Boltzmann-Maxwell.

Fairly soon after the slit ultramicroscope had been developed special condensers were built which made it possible to use the standard type of microscope to determine the presence or absence of colloidal particles.

If the preparation under investigation is composed of nonspherical particles, however, it will be difficult to determine their actual shape. The slit ultramicroscope made this possible because the light enters the preparation only from the side. Nonspherical particles will therefore twinkle, in contrast to spherical particles which would show no change from the point of view of illumination.

Richard Zsigmondy deserves special credit not only for his invention of the slit ultramicroscope but also for having admitted to himself that his original idea was not based on facts.

The science of colloids depends to a great extent on information and experience gained from other fields of science than chemistry. For example, we owe most of our knowledge of the structure of matter to the X-ray diffraction technique. It therefore seems only fitting to explain what actually led Wilhelm Roentgen to make his great discovery.

In 1895 while working in Wurzburg, Roentgen noticed that a barium platinocyanide screen which happened to be lying close to a highly exhausted vacuum tube which was connected with the electric current exhibited pronounced fluorescence. Further investigation showed him that the radiation had the power of passing through various substances which are opaque to ordinary light. He also found that this radiation, which he later termed "X rays", would also cause the darkening of an unexposed photographic plate. For this discovery he received the Rumford Medal of the Royal Society in London in 1896. In 1901 Roentgen also received the Nobel Prize for Physics. His discovery very soon found its application in physics, particularly in evaluating the molecular structure of matter. We owe the most important contributions in this respect to von Laue, and shortly thereafter, to Debye and Scherrer.

One of the greatest contributions in the field of X-ray studies was in studying the structure of rubber. It could readily be shown that if unstretched rubber was subjected to X-ray diffraction, only a simple amorphous band was visible. Upon stretching, however, it became evident that the rubber showed a pronounced alignment in the direction of stretch. Soon thereafter it was ascertained that rubber which has been subjected to freezing would show unoriented zones of "crystalline" structure. It was also possible to prove that if rubber was subjected to very fast expansion, it no longer gave any indication of what was known as an amorphous band. On the basis of this work the so-called multi-phase theory of rubber has been worked out. This theory has demonstrated the function of the plastic phase in rubber. The "plasticizer" is the low molecular weight fraction. In its absence the rubber (natural or synthetic) loses most of its elastic properties.

The science of colloids has also made it possible to develop entirely new techniques for the production of rubber articles. We owe this development entirely to what we have learned about the colloidal condition of rubber latex. It should also not be overlooked that we owe our knowledge of how to produce synthetic rubber emulsions to what the science of colloids has taught us about the natural rubber milk sap.

Ore flotation is another field of applied colloid science. We deal here with ground ore containing nonmetallic ingredients. Depending on the affinity of the ore to certain chemicals which are added to the slurry, it is readily possible to separate the ore from the worthless matter.

In another field, systematic research has revealed that the enzyme hyaluronidase is quite active in the prevention of kidney stones. In the absence of a sufficient quantity of hyaluronidase, stone formation will be accelerated by the growth of crystals or by the agglomeration of the dispersed phase of inorganic colloids. This fact also offers excellent proof that many colloids owe their stability mainly to the electric charge they carry on their surface. Those colloids which are called "hydrophilic" owe their stability primarily to their affinity to water. They will therefore react quite differently from the so-called "hydrophobic," water-hating, colloids. All work carried out along these lines has demonstrated the need of most accurate studies of the electro-kinetic potential carried by colloidal matter.

One could continue almost indefinitely to offer further evidence of the importance of colloid science and why its history is so important. There is almost no modern industry which can afford to disregard the science of colloids. Just to mention a few, the following fields might be referred to: the soap industry; the production of natural and synthetic fibers; the natural and synthetic rubber industry; the entire field of antibiotics; the ceramic industry, where the condition of the clays depends primarily on their surface properties; the ink industry; the brewing of beer; and the colloid-chemical properties of all photographic processes.

Example after example could be offered to give a more detailed discussion of what colloid science actually stands for. It must not be overlooked, however, that it includes far more than just chemistry alone. A basic knowledge of physics, too, for example, is essential for really valuable contributions in these days. The modern colloid scientist needs a well-founded knowledge of both chemistry and physics.

Men working in other fields—in medicine, geology, biology, food technology and many other branches of science — also need at least a smattering of colloid science. Without this knowledge they cannot ascertain if, and to what extent, colloidal phenomena are involved in their problems and how they could be handled. The science of colloids is more far-reaching than most people realize, and from now on more cognizance should be taken of this undeniable fact.

The Spectrum of the Harmonic Oscillator

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In any text on quantum mechanics it is proved that with proper choice of units, the simple harmonic oscillator has eigenvalues $\frac{1}{2}, \frac{3}{2}, \frac{5}{2}, \ldots$. This is usually done by means of solving a boundary value problem. But this implies using a special way of representing states and observables. Closer to the heart of the system are the simple algebraic relations between operators, in particular the commutation rules; even if the scheme of representing states must be complicated, for example to obtain relativistic invariance, the algebra will survive. P. A. M. Dirac showed, in his famous book [Principles of Quantum Mechanics, Oxford Press, 1947] that if we assume that the Hamiltonian operator for the oscillator has a pure point spectrum, it can be proved from the algebraic relations alone that the spectrum consists of $\frac{1}{2}, \frac{3}{2}, \ldots$. In this note we prove from the algebraic relations that the spectrum must necessarily be a pure point spectrum, consisting of exactly the points just mentioned.

From the theory of quantum mechanics we choose a few central concepts. We start with a Hilbert space S; usually this is taken to be the set of functions in the coordinate-space which have integrable squares, but to us this is at present irrelevant. The inner product in S is denoted by parentheses; thus (f,g) is the inner product of f and g, which in the usual interpretation would be the integral of the product of the function f with the conjugate of g. To each physical observable corresponds a self-adjoint operator on S; to each state of a system corresponds a unit vector in S; and when the system is in the state corresponding to the unit vector ψ, and the observable corresponding to operator B is observed, the expected value of the observable is the value of the inner product $(B\psi,\psi)$.

In a one-dimensional system consisting of an object elastically attracted to the origin, let p denote the momentum and q the coordinate of the object. If the units are properly chosen, the total energy is $(p^2 + q^2)/2$. Let P and Q be the self-adjoint operators corresponding to the respective observables p and q: the Hamiltonian operator, corresponding to the total energy, is then

$$H = (P^2 + Q^2)/2. \tag{1}$$

We do not need to know the special form of operators P and Q. But we do need the facts that for every φ to which we can apply H we can also apply P, Q, PQ and QP, and that (with proper units) we then have

$$PQ\varphi - QP\varphi = -i\varphi. \tag{2}$$

Since P, Q, and H are self-adjoint, for each φ and ψ in the domain of H we have $(P\varphi,\psi) = (\varphi,P\psi)$, and so on. But since the inner product has the property $(i\varphi,\psi) = i(\varphi,\psi) = (\varphi,-i\psi)$, we also have

$$(|P + iQ|\varphi,\psi) = (\varphi,|P - iQ|\psi). \tag{3}$$

From (1) and (2) we readily compute that for all φ and ψ in the domain of H,

$$|P - iQ||P + iQ|\varphi = |2H + 1|\varphi. \tag{4}$$

$$[P + iQ][P - iQ]\psi = [2H - 1]\psi. \tag{5}$$

In (5) we choose $\psi = [P + iQ]\varphi$; with the help of (4), (5) becomes

$$[P + iQ][2H + 1]\varphi = [2H - 1][P + iQ]\varphi. \tag{6}$$

Concerning the spectral resolution of H we need the following well-known facts.[1] To each real number u corresponds a projection operator E_u (in another, but not better, terminology $E_u\varphi$ would be the vector obtained by expanding φ in eigenfunctions and eigendifferentials of H and retaining only that part of the expansion corresponding to characteristic numbers $\leqq u$) with the properties

(7) *E_u increases with u and is right continuous; as u tends to ∞, E_u tends to 1, and as u tends to $-\infty$, E_u tends to 0.*

(8) *If $a \leqq b$, then $E_aE_b = E_bE_a = E_a$.*

(9) $\int_{-\infty}^{\infty} d_u(E_u\varphi,\psi) = (\varphi,\psi)$ *for all φ and ψ in S.*

(10) *For all finite a and b, and all φ, $(E_b - E_a)\varphi$ is in the domain of H, and also in the domains of H^2, H^3, etc.*

(11) *For all φ in the domain of H and all ψ in S,*

$$\int_{-\infty}^{\infty} ud_u(E_u\varphi,\psi) = (H\varphi,\psi).$$

Let φ be any vector, and let $\varphi' = (E_b - E_a)\varphi$. By (8), we have

$$\begin{aligned} E_u\varphi' &= E_u\varphi - E_u\varphi = 0 && \text{if} \quad u \leqq a, \\ &= E_u\varphi - E_a\varphi && \text{if} \quad a < u \leqq b, \\ &= E_b\varphi - E_a\varphi && \text{if} \quad u > b. \end{aligned}$$

Hence if we replace φ by φ' in the integrals in (9) and (11), on the range of integration $-\infty < u \leqq a$ the product $(E_u\varphi',\psi)$ is constant, so this contributes nothing to the integral, and likewise for $b < u < \infty$, so we have

$$\int_a^b d_u(E_u\varphi,\psi) = ([E_b - E_a]\varphi,\psi), \tag{12}$$

$$\int_a^b ud_u(E_u\varphi,\psi) = (H[E_b - E_a]\varphi,\psi). \tag{13}$$

If we replace a, b, u by c, d, v, reverse the order in each inner product (which changes it to its complex conjugate) and then interchange letters φ, ψ, these become

$$\int_c^d d_v(\varphi,E_v\psi) = (\varphi,[E_d - E_c]\psi), \tag{14}$$

[1] See, for example, J. von Neuman Mathematische Grundlagen der Quantenmechanik, Dover Publications, 1943.

$$\int_c^d v d_v(\varphi, E_v\psi) = (\varphi, H[E_b - E_a]\psi). \tag{15}$$

Let φ, ψ be any vectors in S, and let $R: a < u \leqq b, c < v \leqq d$ be any rectangle in the plane. For brevity we write

$$f = (E_b - E_a)\varphi, \qquad g = (E_d - E_c)\psi, \tag{16}$$

Then by (3), (10), (12), (13) and (14) we obtain

$$\begin{aligned}(|P + iQ||2H + 1|f,g) &= (|2H + 1|f, |P - iQ|g) \\ &= \int_a^b (2u + 1)d_u(E_u\varphi, |P - iQ|g) \\ &= \int_a^b (2u + 1)d_u(|P + iQ|E_u\varphi, g) \\ &= \int_a^b \int_c^d (2u + 1)d_u d_v([P + iQ]E_u\varphi, E_v\psi).\end{aligned} \tag{17}$$

Similarly from (3), (10), (14), (15) and (12)

$$\begin{aligned}(|2H - 1||P + iQ|f,g) &= \int_c^d (2v - 1)d_v(|P + iQ|f, E_v\psi) \\ &= \int_c^d (2v - 1)d_v(f, |P - iQ|E_v\psi) \\ &= \int_a^b \int_c^d (2v - 1)d_u d_v(E_u\varphi, |P - iQ|E_v\psi).\end{aligned} \tag{18}$$

We again apply (3) to the last, and subtract (18) from (17) member by member: by (6) we obtain

$$0 = 2\int_a^b \int_c^d (u - v + 1)d_u d_v(|P + iQ|E_u\varphi, E_v\psi). \tag{19}$$

Now let us introduce a factor $f(u,v)$ under the integral sign in (19), producing a symbol

$$\int_a^b \int_c^d f(u,v)(u - v + 1)d_u d_v(|P + iQ|E_u\varphi, E_v\psi). \tag{20}$$

If f is a constant, this is 0 by (19). If f is a step-function, meaning that R can be cut into finitely many sub-rectangles on each of which f is constant, then by applying (19) to each small rectangle we find that the integral over each is 0, so when we combine them we find that (20) is still 0. If $f(u,v)$ is continuous in R and on its boundary, it can be uniformly approximated by a sequence of step-functions $f_1, f_2, \ldots$. For each f_n the integral (20) (with f_n in place of f) vanishes, so the limit (20) also is 0. Now suppose that $u - v + 1$ does not vanish in R or on its boundary. Then we can choose $f(u,v) = 1/(u - v + 1)$, and (20) will still vanish. But now the integration is easy; we obtain

$$(21) \qquad ([P + iQ][E_b - E_a]\varphi, [E_d - E_c]\psi) = 0$$

if the rectangle $a \leqq u \leqq b$, $c \leqq v \leqq d$ does not meet the line $u - v + 1 = 0$. By (3) this can be written

$$(\varphi, [E_b - E_a][P - iQ][E_d - E_c]\psi) = 0.$$

But φ is arbitrary, so

$$(22) \qquad [E_b - E_a][P - iQ][E_d - E_c]\psi = 0$$

for a, b, c, d as described. By an easy limiting process we find that we can replace b by $+\infty$ or a by $-\infty$ provided that the set $a \leqq u \leqq b$, $c \leqq b \leqq d$ does not meet the line $u - v + 1 = 0$.

Now let λ be a point which belongs to the spectrum of H, while $\lambda - 1$ does not. We can choose a small interval $a \leqq u \leqq b$ centered about $\lambda - 1$ for which $E_b = E_a$, since $\lambda - 1$ is not in the spectrum. Let $c \leqq v \leqq d$ be a still smaller interval centered on λ. Since λ is in the spectrum, $E_d \neq E_c$, and there is a non-zero vector ψ in the range of the projection $E_d - E_c$. Then $[E_d - E_c]\psi = \psi$. Since neither the set $-\infty < u \leqq a$, $c \leqq v \leqq d$ nor the set $b \leqq u < \infty$, $c \leqq v \leqq d$ contains any point with $u - v + 1 = 0$, we have by (22)

$$[E_a - 0][P - iQ][\psi] = 0,$$

$$[1 - E_b][P - iQ][\psi] = 0,$$

and since $E_b = E_a$,

$$[E_b - E_a][P - iQ]\psi = 0.$$

Adding these three equations yields

$$[P - iQ]\psi = 0.$$

Hence $[P + iQ][P - iQ]\psi = 0$, or by (5) $[2H - 1]\psi = 0$. That is, $H\psi = \frac{1}{2}\psi$, and ψ is a characteristic vector belonging to the characteristic number $\frac{1}{2}$.

It is easy to see that the two facts: (a) ψ is in the range of $E_d - E_c$ and (b) ψ belongs to $\frac{1}{2}$ combine to prove that $\frac{1}{2}$ is in the interval $[c,d]$. But $[c,d]$ is an arbitrarily small interval centered on λ; and if every such interval contains the point $\frac{1}{2}$, then λ must itself be $\frac{1}{2}$. Thus we have shown that *if* λ *is in the spectrum and* $\lambda - 1$ *is not, then* $\lambda = \frac{1}{2}$.

The spectrum contains a smallest number λ_0. Then $\lambda_0 - 1$ is not in the spectrum; so $\lambda_0 = \frac{1}{2}$. Now for each λ such that $\frac{1}{2} < \lambda < \frac{3}{2}$, $\lambda - 1$ is not in the spectrum (being less than the least number $\frac{1}{2}$ in the spectrum), so λ cannot be in the spectrum, not being $\frac{1}{2}$. So there is no point of the spectrum between $\frac{1}{2}$ and $\frac{3}{2}$. In the same way there is none between $\frac{3}{2}$ and $\frac{5}{2}$, and so on. The only points which can possibly be in the spectrum are the points $(2n - 1)/2$, $n = 1, 2, 3, \ldots$. Suppose one of these, say $(2m - 1)/2$, is not in the spectrum. Take this as $\lambda - 1$; if λ were in the spectrum it would have to be $\frac{1}{2}$, which it is not, so $(2m + 1)/2$ would also be lacking, and so on. That is, if any of the points $\frac{1}{2}, \frac{3}{2}, \frac{5}{2}, \ldots$ is out of the spectrum so are all later ones. Then the spectrum of H would have a greatest value, and H would be bounded, which it is not; so we see that the spectrum of H consists of all the numbers $\frac{1}{2}, \frac{3}{2}, \frac{5}{2}, \ldots$ and of no others.

Lipotropic Action of Vitamin B_{12} In the White Rat[1]

J. C. FORBES AND O. PATTERSON

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Drill and McCormick (1949) found that subcutaneous administration of a vitamin B_{12} concentrate to rats on a 16 per cent protein and 51 per cent lard diet exerted a considerable lipotropic effect. Gyorgy and Rose (1950) showed that if 0.5 microgram of vitamin B_{12} were given daily by mouth to rats on a low-fat diet a significant lipotropic effect was obtained but they were unable to demonstrate any lipotropic effect when the diet was high in fat. Gyorgy, however, in a recent publication (1951) has reported that if the vitamin B_{12} intake is high, namely 20 micrograms per day, a good lipotropic effect is obtained even though the animals are on a high fat diet. Lucas, Ridout, Patterson, and Best (1951) studied the interrelationship among choline, vitamin B_{12}, and folic acid by supplementing a hypolipotropic basal diet with each separately, at different levels, and in various combinations. They were unable to demonstrate any effect of vitamin B_{12} on liver lipids under their experimental conditions. Hale and Schaefer (1951) on the other hand, found that vitamin B_{12} plus folic acid exerted a marked lipotropic effect when they were both given along with a suboptimum amount of choline. Burns and McKibbin (1951) showed that vitamin B_{12} exerted a definite lipotropic action in weanling puppies.

In view of the fact that there is diversity of opinion regarding the lipotropic action of vitamin B_{12}, it would seem worth while to publish some of the results which we have obtained on the lipotropic action of this member of the vitamin B complex. Our results clearly confirm the lipotropic effect of vitamin B_{12} in the white rat.

Experimental procedure—Young albino rats of both sexes raised in our own colony were used in nearly all of the experimental work. The initial weight of the animals on the 5 per cent fat diets was nearly all between 40 and 50 grams. Those on the 40 per cent fat diet were started a little heavier, weighing between 60 and 70 grams, since very young rats do very poorly on such a high fat–low protein diet. At the conclusion of the experimental period, the animals were sacrificed and their livers analyzed separately for cholesterol and neutral fat by a previously described procedure (Outhouse and Forbes, 1940). Results are expressed as percentages of the fresh liver weight. Since there was no apparent difference in response between sexes, the results obtained on all animals in a particular group have been averaged without regard to sex in compiling the data shown in Table I.

The composition of the basal diet was as follows: vitamin-free casein 100 gm., Crisco 50 gm., sucrose 803 gm., Cellu flour 20 gm., and Wesson salt mixture 27 gm., plus the following vitamins in milligrams/kg. of diet: thiamine hydrochloride 4, riboflavin 8, niacin 14, pyridoxine hydrochloride 6, calcium pantothenate 14, Menadione 10, biotin 5 and folic acid 5. Each

[1] Presented at the Annual Meeting of the Virginia Academy of Science, May, 1952.

animal received in addition one drop of Oleum Percomorphum (Mead, Johnson and Co.) five times per week plus one drop of wheat germ oil reinforced with 60 mg. of alpha tocopherol per cubic centimeter once a week. Any increase in either the casein or Crisco was at the expense of an equal weight of sucrose. Other supplements were as shown in Table I.

TABLE I. Effect of Vitamin B_{12} on the Neutral Fat and Cholesterol Content of the Liver of the Albino Rat.

Number of rats	Days on diet	Average daily gain in wt.	Liver		Remarks
			Neutral fat %	Cholesterol %	
6	20	0.5	17.2 ± 4.4*	.55 ± .06*	Basal diet (5% fat)
8	20	1.3	7.8 ± 2.0	.44 ± .11	Same+60 mcg. B_{12}/kg. of diet
5	28	1.0	27.3 ± 7.4	.64 ± .11	Basal diet (5% fat)
10	28	1.4	7.0 ± 3.0	.46 ± .12	Same+60 mcg. B_{12}/kg. of diet
10	28	1.4	8.9 ± 1.8	.51 ± .15	Basal diet+.025% choline and inositol
10	28	1.5	3.8 ± 0.8	.40 ± .09	As above+60 mcg. B_{12}/kg. of diet
8	30	2.0	13.4 ± 3.4	.51 ± .17	Basal diet but 15% casein
10	30	2.7	5.1 ± 2.7	.43 ± .19	Same+60 mcg. B_{12}/kg. of diet
10	34	1.8	4.8 ± 1.9	.33 ± .14	Basal diet but 15% casein + .025% choline and inositol
9	34	2.2	3.4 ± 2.1	.28 ± .06	As above+60 mcg. B_{12}/kg. of diet
9	39	0.4	38.3 ± 3.3	.95 ± .14	Basal diet but 40% fat
8	39	0.4	31.2 ± 4.3	.86 ± .12	As above+60 mcg. B_{12}/kg. of diet
18	27	0.7	17.5 ± 7.0	.55 ± .11	Basal diet but 40% fat
18	27	0.6	16.3 ± 9.2	.48 ± .14	Same + .025% choline and inositol
17	27	1.3	6.7 ± 3.6	.39 ± .15	As above + 60 mcg. B_{12}/kg. of diet

* Standard deviation

It will be seen that vitamin B_{12} in the concentrations used exerted a marked lipotropic effect in the absence of other lipotropic agents when the diet was relatively low in casein and fat. When the diet contained 10 per cent casein and 40 per cent fat, vitamin B_{12} in the concentrations used

showed no definite lipotropic effect if choline and inositol were absent from the diet. When the diet contained .025 per cent of both of these substances, however, the lipotropic effect of vitamin B_{12} became quite obvious. Gyorgy (1951), as already mentioned, has shown that if the vitamin B_{12} intake is high, 20 micrograms per day, no additional lipotropic agents are necessary in order to demonstrate its lipotropic effect in rats on a high fat diet. It would appear that the difference noted in the lipotropic action of vitamin B_{12} in animals on a low fat and high fat diet is probably altogether a result of the increased lipotropic requirement as the fat content of the diet is increased. Thus an amount of lipotropic activity sufficient to show a definite response in animals on a low fat diet would be wholly inadequate if the diet were high in fat.

Summary.—Addition of 60 micrograms of vitamin B_{12} per kilogram of diet has been found to exert a distinct lipotropic effect in the young white rat when the diet contains only 5 per cent fat. This amount of vitamin B_{12} exerted no definite lipotropic effect, if fed as the sole lipotropic agent, when incorporated in a diet containing 40 per cent fat. When the high fat diet contained .025 per cent choline and inositol respectively, however, the further addition of 60 micrograms of vitamin B_{12} per kilogram of diet exerted a good lipotropic effect.

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COMPRESSIBLE VISCOUS FLUIDS[1,2]

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Equations describing the flow of a compressible viscous fluid have been formulated by several authors.[4] The equation of momentum includes two viscosity coefficients which are analogous to Lamé's constants of elasticity (Szebehely and Pletta, 1950). For monatomic gases, a relation exists between the viscosity coefficients. If this relation is introduced into Duhem's equation, the classical Navier-Stokes equation results. Illingworth (1950) reported the results of investigations of a few problems regarding compressible viscous flow of gases using the above mentioned special relation between the viscosity coefficients. In the present paper, no relation is assumed between viscosity coefficients; therefore, the following results are applicable to polyatomic gases and liquids. On the other hand, no thermal effects will be considered in this paper, and physical constants of the fluids investigated are assumed to be constant.

Since compressible fluids are investigated and no relation is assumed between the viscosity coefficients, the effect of the second coefficient of viscosity can be studied.

BASIC EQUATIONS FOR VISCOUS COMPRESSIBLE FLUIDS

Three unknowns are considered, the velocity vector $\bar{v}$, (with components u, v and w in a rectangular Cartesian coordinate system), the pressure p and the density ρ. Three equations are used to relate the above unknowns to the space coordinates (x, y, z) and to the time, t. The equations are the conservation of mass, or the so-called continuity equation, the Navier-Poisson-Duhem, or the so-called momentum equation, and the equation of state, which connects pressure and density.

The continuity equation is

$$\frac{\partial \rho}{\partial t} + \operatorname{div}(\bar{v}\rho) = 0 \tag{1}$$

or using Cartesian rectangular coordinates:

$$\frac{\partial \rho}{\partial t} + \frac{\partial(\rho u)}{\partial x} + \frac{\partial(\rho v)}{\partial y} + \frac{\partial(\rho w)}{\partial z} = 0 \tag{1a}$$

The Navier-Poisson-Duhem equation is obtained if the stress tensor is introduced into the equation of motion. The elements of the stress tensor are:

[1]The investigation reported in this paper was aided by a Grant-in-Aid from the Sigma Xi-Resa Research Fund to the author.
[2]Presented at the Annual Meeting of the Virginia Academy of Science, May, 1951.
[3]Presently: David Taylor Model Basin, Navy Department.
[4]See Duhem, 1901.

$$p_{ij} = -\delta_{ij}p + \delta_{ij}\lambda u_{k,k} + \mu(u_{i,j} + u_{j,i}) \quad \text{or}$$

$$\left.\begin{aligned}
\sigma_x &= -p + \lambda \operatorname{div} \bar{v} + 2\mu \frac{\partial u}{\partial x} \\
\sigma_y &= -p + \lambda \operatorname{div} \bar{v} + 2\mu \frac{\partial v}{\partial y} \\
\sigma_z &= -p \equiv \lambda \operatorname{div} \bar{v} + 2\mu \frac{\partial w}{\partial z} \\
\tau_{xy} &= \tau_{yx} = \mu\left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}\right) \\
\tau_{yz} &= \tau_{zy} = \mu\left(\frac{\partial v}{\partial z} + \frac{\partial w}{\partial y}\right) \\
\tau_{zx} &= \tau_{xz} = \mu\left(\frac{\partial w}{\partial x} + \frac{\partial u}{\partial z}\right)
\end{aligned}\right\} \tag{2}$$

Making use of equations (2), the momentum equation is obtained:

$$\rho\left(\frac{\partial \bar{v}}{\partial t} - \bar{g}\right) = -\operatorname{grad} p - \rho \operatorname{grad} \frac{\bar{v}^2}{2} + \rho\, \bar{v} \times \operatorname{curl} \bar{v} + (\lambda + 2\mu) \operatorname{grad} \operatorname{div} \bar{v} - \mu \operatorname{curl} \operatorname{curl} \bar{v}. \tag{3}$$

Here g is the external force vector per unit mass, μ is the first (ordinary) coefficient of viscosity and λ is the second coefficient of viscosity. The three coordinates of equation (3) using rectangular Cartesian coordinates are:

$$\left.\begin{aligned}
\rho\left(\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} + w\frac{\partial u}{\partial z}\right) &= -\frac{\partial p}{\partial x} + \rho g_x + \mu \Delta u \\
&\quad + (\lambda + \mu)\frac{\partial}{\partial x}\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z}\right)
\end{aligned}\right\} \tag{3a}$$

$$\left.\begin{aligned}
\rho\left(\frac{\partial v}{\partial t} + u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y} + w\frac{\partial v}{\partial z}\right) &= -\frac{\partial p}{\partial y} + \rho g_y + \mu \Delta v \\
&\quad + (\lambda + \mu)\frac{\partial}{\partial y}\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z}\right)
\end{aligned}\right\} \tag{3b}$$

$$\left.\begin{aligned}
\rho\left(\frac{\partial w}{\partial t} + u\frac{\partial w}{\partial x} + v\frac{\partial w}{\partial y} + w\frac{\partial w}{\partial z}\right) &= -\frac{\partial p}{\partial z} + \rho g_z + \mu \Delta w \\
&\quad + (\lambda + \mu)\frac{\partial}{\partial z}\left(\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z}\right)
\end{aligned}\right\} \tag{3c}$$

The equation of state connects the pressure and the density $\rho = f(p)$.

In the conventional Navier-Stokes equation, the $\lambda = -\frac{2}{3}\mu$ relation is assumed. For incompressible fluids, the continuity equation gives

$$\operatorname{div} \bar{v} = 0,$$

and therefore, the second viscosity coefficient has no effect. (See equations (2), (3), (3a), (3b) and (3c).)

The average compressive stress can be defined as one third of the first invariant of the stress tensor (2):

$$p_m = -\frac{\sigma_x + \sigma_y + \sigma_z}{3},$$

where the minus sign is used because positive stresses are connected with tensile stresses. From equations (2)

$$p_m = p - (\lambda + \tfrac{2}{3}\mu) \operatorname{div} \bar{v}$$

or

$$p - p_m = (\lambda + \tfrac{2}{3}\mu) \operatorname{div} \bar{v} \tag{4}$$

Equation (4) gives $p = p_m$ for incompressible fluids, *i.e.*, the average compressive stress and the pressure are identical. This is also true if the $\lambda = -\frac{2}{3}\mu$ relation is assumed. Actual measurements showed that the $\kappa = \lambda + \frac{2}{3}\mu$, "volume viscosity" (as defined by Reiner, 1951) is not zero for liquids and that its value varies for different fluids (Truesdell, 1952).

SPECIAL CASE

It is interesting to show the effect of viscosity in a classical compressible flow problem. The basic equation of two dimensional gas dynamics is

$$\phi_{xx}(c^2 - \phi_x^2) + \phi_{yy}(c^2 - \phi_y^2) - 2\phi_x\phi_y\phi_{xy} = 0, \tag{5a}$$

where ϕ is the potential function ($\operatorname{grad}\phi = \bar{v}$) and c the velocity of sound. The derivation of this equation uses: (1) the Euler equation for steady flow of non-viscous fluids, neglecting body forces and assuming potential flow:

$$\rho \operatorname{grad}\frac{\bar{v}^2}{2} = -\operatorname{grad} p,$$

(2) the continuity equation for the steady flow of compressible fluids:

$$\operatorname{div}(\rho\bar{v}) = 0,$$

(3) The equation for the velocity of sound:

$$c = \sqrt{\frac{dp}{d\rho}}.$$

If the usual linearization is performed, equation (5a) becomes

$$\phi_{xx}(1 - M^2) + \phi_{yy} = 0, \tag{5b}$$

where $M = U/c$ is the free stream Mach number and U the free stream velocity. The linearization process assumes the velocity components in the form:

$$\frac{\partial\phi}{\partial x} = \phi_x = u = U + u' \qquad \text{and} \qquad \frac{\partial\phi}{\partial y} = \phi_y = v = v'$$

where u' and v' are "second order small" quantities.

In the subsonic case ($0 < M < 1$) with the

$$\xi = \frac{x}{\sqrt{1 - M^2}}, \qquad \eta = y$$

substitution (5b) goes over to the Laplace equation:

$$\phi_{\xi\xi} + \phi_{\eta\eta} = 0 \tag{5c}$$

The basic equation for the steady flow of viscous, compressible fluids, neglecting body forces is obtained if (1) the special case of equation (3):

$$\rho \operatorname{grad} \frac{\bar{v}^2}{2} = -\operatorname{grad} p + (\lambda + 2\mu) \operatorname{grad} \operatorname{div} \bar{v}$$

(2) the continuity equation:

$$\operatorname{div} (\rho \bar{v}) = 0$$

(3) and the equation for the velocity of sound:

$$c = \sqrt{\frac{dp}{d\rho}}$$

are combined. Since $p = p(\rho)$, therefore $c = c(\rho)$ or $\rho = f(c)$.

The new basic equation is

$$\phi_{xx}(c^2 - \phi_x^2) + \phi_{yy}(c^2 - \phi_y^2) - 2\phi_x\phi_y\phi_{xy} = -\frac{\lambda + 2\mu}{f(c)} (\phi_x \Delta\phi_x + \phi_y \Delta\phi_y) \tag{6a}$$

If viscosity is not considered, then the right side of equation (6a) disappears and equation (5a) is obtained.

Making the same linear assumptions as before, equation (6a) is

$$\phi_{xx}(1 - M^2) + \phi_{yy} = -\frac{\lambda + 2\mu}{cf(c)} M(\Delta\phi)_x \tag{6b}$$

Equation (6b) cannot be changed to the simple form of equation (5c), in fact equation (6b) is a third order partial differential equation. The third order terms represent the viscous effects.

SUMMARY

In the paper, the general form of the Navier-Poisson-Duhem equation was presented and applied for special flow problems regarding viscous compressible fluids. The basic equations become very much involved even when linearization is performed. The effect of the second coefficient of viscosity was studied. It was shown that if either viscosity or compressibility are neglected, the second viscosity coefficient disappears from the equations. Monatomic gases, due to the $\lambda = -\frac{2}{3}\mu$ relation, are not suitable for studying the effect of the second coefficient of viscosity. Water, however, very little compressible seems to be a better medium since its viscosity is more prominent than that of gases. The existence of potential flow of compressible viscous fluids was assumed in the paper.

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Experiences of the Multiphasic Screening Program from a Laboratory Standpoint in Richmond, Virginia

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"Screening," as used in this paper, is the application of presumptive laboratory tests and clinical procedures to an individual to detect suspicious evidence of a disease or abnormal condition. Definitive diagnostic procedures are instituted to establish whether or not the suspect becomes a case if evidence through screening so indicates. "Mass Screening" is the same technique applied to the population at large.

The objective of a mass screening program is to detect the presence of one or more asymptomatic diseases or conditions in individuals being screened. It is the outgrowth of the recognition by the medical and related professions of the necessity of approaching the ever increasing chronic disease problem with a combined community effort. The results of delayed diagnosis and treatment are a high mortality and morbidity rate in a community. The early detection of diseases, while they are still in the asymptomatic stage, means less needless suffering, less loss of life, and decreased medical expense.

In recent years, as laboratory science has progressed, the use of less specific tests of high sensitivity has become accepted practice in the selection of individuals for comprehensive medical examination. The value of this concept was not generally recognized until the impact of mass blood testing for syphilis and chest X raying for tuberculosis made such procedures widely acceptable. It is now well recognized that the application of clinically reliable examination techniques to the apparently well population is an accepted case finding procedure. Thus, mass screening, as it has become known in the popular sense, depends upon laboratory test procedures of high sensitivity which can be performed rapidly and economically. Effective screening procedures must be sufficiently selective to reveal presence of the condition being tested, and at the same time, be sufficiently accurate to eliminate false positives. The tests should be easy to perform, permit speed in collection of the samples, and should not cause undue inconvenience to the person being tested. If these prerequisites can be fulfilled various multiples can be added to suit the specific needs of a community.

The use of more than one test on any given group of the population is not new, although it is only within recent years that it has increased in popularity. The first linkage of tests came when in 1939 the tobacco industry of Richmond was surveyed for the combined detection of tuberculosis and syphilis. Later, in other areas more test procedures such as blood sugar for diabetes were added to this procedure.

In the spring of 1949, the Division of Chronic Diseases of the United States Public Health Service planned five mass population surveys for chronic diseases. Four of these were located in urban areas and one in a

rural area. The urban projects were Framingham, Massachusetts; Flattermouth, Indiana; Atlanta, Georgia; and Richmond, Virginia. The rural project was planned for selected counties in Alabama. The Richmond project was the first large scale mass screening program to get underway. Tests were conducted for the following conditions: syphilis, tuberculosis and other chest conditions, heart diseases, hypertension, anemia, diabetes, obesity, visual acuity, and intraocular tension. In addition, every tenth person was given an electrocardiogram with twelve leads as a part of a special study.

There is no set rule on what may or may not be included in the mass screening of population. The ones chosen for Richmond were selected because they seemed most pertinent to the locality. The consensus of all concerned with the planning of the multiphase program in Richmond was that only acceptable laboratory procedures should be used in the mass screening program. It was felt that while new procedures could be used to evaluate, they should be checked by standard procedures, and in case of variance, the latter results be used for reporting. Full approval for participation in the program was obtained from the Richmond Academy of Medicine, and every procedure used in the program was approved and accepted by an advisory committee of the Academy.

Although it was recognized that most of the examinations were performed at the screening clinic, urine examinations for diabetes and the blood serology for syphilis were performed more economically and with less effort at the main laboratory.

There was considerable insistence to do blood sugars rather than urine sugars. Despite this insistance it was decided to do urine sugars because there could be no control over meal time of the persons going through the clinic, and because the sugar threshold of urine is higher than that of blood. Consequently, blood sugars would result in too many false positive reactions. Since all positive results were to be rechecked at the individual's expense in private laboratories, too many positives due to over sensitivity, might lessen the effectiveness of the program. This has since been proven correct in the use of the Wilkerson and Heftmann test, as the levels of the reagents have been lowered to 160 and 180 mg. in order to reduce the sensitivity to normal limits.

In addition, the machine used in the Wilkerson and Heftmann test, and known by the nick-name, "Tillie, the Tin Technician," was not available at the time, and other methods were too slow and would require too much personnel.

In choosing a technique where large volumes of urine could be handled in an accurate manner by a small and not too technically trained personnel, the use of Clinitest tablets was picked as most suitable. It was found that one technician could handle, under pressure, 525 specimens per day, althought the usual number was about 450. This included numbering the specimen and report slip, examining the specimen, and recording the result. All reactors were rechecked before reporting the results.

In a test conducted by the U. S. Public Health Service at our laboratories in May, 1950, in a comparison study of 1500 specimens of blood and urine, only twelve discrepancies were revealed. Daily capacity of both tests was about 400 to 450. To maintain a steady run of the machine, however, would necessitate one person to dilute the blood or sera, one person to run

the Wilkerson and Heftmann machine and read the results, and one person to wash the glassware.

Blood serologies were made by the Kahn procedures, using the Kahn presumptive test as a screen and rechecking all reactors with the three-tube Kahn standard test. No quantitative tests were performed on the screening specimens. Due to scarcity of trained public health laboratory workers, the increased work load was offset by the use of college graduates in doing non-technical work——such as numbering specimens, centrifuging, inactivating sera, and setting up the runs for the experienced workers to complete and read. These college graduates were untrained. As time permitted, they were trained to pipette and do other semi-technical work.

At the clinic, the Dare Hemoglobinometer was used because the sensitivity was high enough for screen testing, and it provided the fastest method of determination. At the blood table three graduate nurses took blood pressure readings and drew blood specimens while on volunteer, with previous experience in making hemoglobin tests, kept pace with all three. A special narrow cuff used to take the blood pressure served as a tourniquet for taking the blood specimens. The choice of the B-D vacutainer was an excellent one. Since no blood was spattered around the blood table and since the people were processed rapidly, the number of persons fainting at the sight of blood was held to a minimum. Of 15,000 persons examined during the first month, only two became sick, and neither of these fainted. The use of previously sterilized tubes made unnecessary the washing and sterilizing of syringes at the clinic site. The reuse of the 13x100 mm. size vacutainer tubes at the laboratory further offset the original cost.

During the multiple screening program, the City Laboratory acted as a service center for the clinic: preparing specimen containers for urinalysis; washing and sterilizing needles; supplying vacutainers, clean linen, office supplies, *et cetera*. The choice of urine containers presented somewhat of a problem. A single unit screw-cap aluminum container, similar to those used by insurance companies, were unavailable. Since tests for sugar alone were being made, and as the total amount of urine needed was only ten drops, the blood serology container was ideal. A small thymol preservative tablet in a sterile 13x100 mm. corked test tube was found to be adequate. Request slips were not used since a space for a serial number was provided on the mailing label.

Vacutainer needles were washed, dried, wrapped in cotton gauze, and sterilized eight to a petri dish. These were transported to the clinic and kept there in petri dish holders of thirty plates each. After use the needles were dropped in cold haemosol solution in gallon jars and returned to the laboratory for rewashing and sterilizing.

At the peak load the additional employees necessary to carry on work amounted to two semi-technically trained technicians in the serology laboratory, one technician for the urinalysis, two maids to help with the glassware washing and sterilizing of needles, and one additional person in the container room.

Results of the screening program in Richmond, which lasted from January, 1950, until August, 1950, were quite interesting and enlightening. Of the total of 37,609 persons who were examined in the clinic, 24,496 or

65% had no abnormalities; 13,113 or 35% were suspects for one or more diseases.

In a more definitive examination of the results of the individual examinations, the Kahn presumptive test for syphilis segregated 322 persons, or 0.8% of the group for further investigation. From past experience in this area, one would have expected 2% positivity. It should be considered, however, that in an overall study of the economic status of the persons tested, the majority were well above the median and were not in a group which would normally give a higher percentage of syphilis. This, coupled with the fact that the Kahn test is of lower sensitivity than some of the newer cardiolipin tests, resulted in a lower figure than expected.

Urine tests for diabetes gave 347 positive reacters and 170 doubtfuls from 35,010 persons tested, a percentage of 1.4%.

Considering 12.0 gms. percent as lower limit of normal, hemoglobin determinations gave 4,914 readings out of 37,081, or 13.2% as abnormal.

Blood pressures were taken on 37,177 persons, using 150/100 as high limits. There were 5,370 persons or 11.7% with an elevation of either the systolic or diastolic over these levels, and of these 1,667 had both systolic and diastolic readings higher than these levels.

Of the 30,434 chest x-rays taken which were read for total pathology, 1,290 were classified as abnormal as to findings pertaining to the lungs, and 1,561 to the heart. In the re-x-raying on 14x17 film of 1,155, 496 persons showed definite pathology due to tuberculosis, and 300 showed other abnormalities. In the group of cardiac suspects, 245 were re-x-rayed using larger film, but only 32 of these were ruled out as negative.

On the basis of 37,000 persons tested, the Richmond experience showed a cost of $1.79 a person.

Space allotted for this paper does not permit a complete breakdown of results as to sex, age, color, and economic status, or the comprehensive results of follow-up examination by private physicians.

It is hoped that the experience of our laboratory in this pilot study may prove useful to anyone contemplating a similar program. Consideration should be given to the following points: first, do not try to carry too great a load at the expense of the normal routine work without adequate help, both in trained reserve personnel and in enough non-technical support to allow full use of your technical knowledge; second, be sure to have adequate service personnel to take care of washing, sterilizing and preparation of supplies for the clinic; and third, do not allow the clinic to take more specimens than the laboratory can handle.

News and Notes

(Editor's note: News contributions should be sent to the person whose name appears at the end of the appropriate section.)

NEWS FROM THE EDITOR-IN-CHIEF

The Council, at its meeting in Lexington on October 12, 1952, agreed that in the Proceedings for 1952-1953—to be published in the September, 1953, Virginia Journal of Science—(a) all abstracts are to be limited to 150 words, and (b) all reports are to contain no more than 400 words, with the exception of those reports in which publication of audits, as well as those reports containing names of persons receiving awards—these exceptions required by the Academy.

It is requested that those members of the Academy submitting abstracts keep this information in mind, and that each committee chairman prepare a summary of less than 400 words of his report for inclusion in the Journal.

THIRTY-FIRST ANNUAL MEETING OF THE VIRGINIA ACADEMY OF SCIENCE

The following committee chairman will serve in arranging for the 1953 meeting of the Academy which will be held at the Virginia Military Institute, Lexington, on May 6, 7, 8, and 9.

General Chairman	Col. S. M. Heflin
Housing	Lt. Col. George B. Ax
Registration and Information	Col. R. C. Weaver
Traffic and Parking	Maj. L. L. Nichols
Junior Academy Exhibits	Lt. Col. J. B. Newman
Meeting Rooms and Equipment	Col. I. G. Foster
Commercial Exhibits	Mr. D. R. Carpenter
Field Trips	Col. R. P. Carroll
Special Dinners and Luncheons	Col. R. P. Carroll
Signs and Maps	Maj. S. W. Dobyns
Parades	Maj. L. L. Nichols
Entertainment (Ladies)	Mrs. S. W. Anderson

RESEARCH COMMITTEE

Encouragement of research in Virginia has always been one of the chief objectives of the Academy. Research Grants-in-Aid, and also the annually available J. Shelton Horsley Research Award, are offered by the Academy to encourage and stimulate research work of its members. The attention of Academy members is called to the availability of both the Grants-in-Aid and the award. The Research Committee urges the interest and participation of members in both.

RESEARCH GRANTS-IN-AID

The income from the Academy's Endowment Fund is set aside each year to provide assistance to Academy members who submit to the Research Committee worthy research problems for which financial aid is needed. Research grants have varied in amount but during recent years have averaged approximately $150.00 each.

The applicant is requested to outline his problem and list the items for which assistance is required. The names and addresses of three persons who know his qualifications for scientific research should be submitted with his request.

Grants will be made on the basis of (1) apparent merit of the research project, and (2) the need of the grant to aid in carrying out a project, or some portion of it. Worthy problems being investigated by younger members and by members on staffs of smaller schools — as well as investigations by older members and by those on staffs of larger institutions — will be given full consideration in the awarding of grants.

Since funds are now available, the committee urges that applications be mailed at an early date to W. S. Flory, Jr., Boyce, Virginia, so that they may be considered at its next meeting.

J. SHELTON HORSLEY RESEARCH AWARD

Members of the Academy and officers of the Sections are requested to give thought to the entering of papers for the 1953 Horsley Research Award. The only requirements for eligibility for the J. Shelton Horsley Research Award are that submitted papers shall (1) present original research (2) by Academy members (3) at the annual May meeting, and (4) that the paper deals either with unpublished data or be a published work — if publication was not prior to May of the previous year (which would be May 1952 in the present case.)

The Section Officers are again asked to serve as advisors to the Research Committee and to pass on to it papers which they deem prize-worthy, even though they are not formally submitted for the award. This procedure in 1950, 1951, and 1952 has had the fine cooperation of all sectional officers concerned and has resulted in a marked increase in the number of papers considered.

Papers to be submitted in competition for the J. Shelton Horsley Research Award should be prepared in duplicate and sent to the Secretary of the Section concerned. The deadline date for getting such papers to the Secretaries will probably be April 1, 1953. Definite announcement of this date will be sent out by the Sectional Secretaries.

The 1953 J. Shelton Horsley Research Award will consist of (1) a Certificate from the Academy engraved with the name of the winner and signed by the current officers of the organization; and (2) a check in the amount of one hundred ($100.00) dollars.

The Horsley Award is one of the top prizes available to scientists in Virginia. The widespread interest and participation of members in the seeking of this award will mark a healthy condition with respect to the type of research work being carried out in the State. Such interest and participation is desired and solicited.—W. S. FLORY, JR., *The Blandy Experimental Farm, University of Virginia, Boyce, Virginia*

SECTION NEWS

AGRICULTURAL SCIENCE SECTION

Dr. R. W. Engel has been appointed Head of the Department of Biochemistry and Nutrition at the Virginia Polytechnic Institute. Dr. Engel is a native of Wisconsin. He received a Ph. D. degree in zoology and medical science from the University of Wisconsin in 1937 and a Ph. D. degree in biochemistry and nutrition from the same institution in 1939. Dr. Engel has served as Associate Professor and Professor of Animal Nutrition at the Alabama Polytechnic Institute since 1939 with the exception of two years spent in military service in the Pacific Theatre during World War II.

Under the direction of Dr. Engel the reorganized Department of Biochemistry and Nutrition at V. P. I. will be responsible for conducting investigations in cooperation with the Animal Husbandry, Dairy Husbandry, Poultry Husbandry, Home Economics, Horticulture, Agronomy, and Biology Departments. He and his staff will do much needed research on livestock, poultry, and human nutrition.

Several members of the Department of Horticulture attended the annual meeting of the American Society for Horticultural Science which was held at Cornell University in connection with the A. I. B. S. meeting in September. Dr. Wesley P. Judkins was elected to the Executive Committee of the A. S. H. S. The following papers were presented by members of the Department of Horticulture at the Cornell meeting: (1) Pine Mouse Control Based on Trail Concentrations, by Frank Horsfall, Jr.; (2) A New Subjective Judging Method as Applied to Horticultural Produce, by George E. Mattus; and (3) Viability of Fruit Pollens as Shown in Tests Employing 2, 3, 5-Triphenyl Tetrazolium Chloride, by G. D. Oberle and Richard Watson.

Several changes have taken place in the staff of the Animal Husbandry Department at V. P. I. Mr. Frank McClaugherty has moved from the Front Royal Beef Cattle Research Station to V. P. I. Jock Taylor has moved from the Holland Experiment Station to the Front Royal Station. Horace Thomas has returned to the Holland Experiment Station from his leave of absence, during which he was studying for his M. S. degree. Dr. R. L. Arthaud of Missouri has been appointed Assistant Professor in the Animal Husbandry Department effective September 1, 1952, and is located at the Front Royal Beef Cattle Research Station.

Several members of the Animal Husbandry Department at V. P. I. attended the annual meeting of the American Society of Animal Production which was held in Chicago. The following papers were presented: (1) Heritability of Rate of Gain from Progeny Tests with Beef Cattle, by C. M. Kincaid, R. C. Carter, and J. S. Copenhaver; and (2) Live Animal Scores and Split Carcass Measurements as Indicators of Carcass Value in Swine, by R. L. Arthaud and G. E. Dickerson (Missouri).

Professor C. W. Holdaway retired as Head of the Dairy Department, V. P. I., on October 1, 1952, with over 40 years' service to the dairy industry. Upon his retirement, Dr. G. C. Graf assumed the duties and responsibilities of the Head of the Dairy Department. Dr. Graf received his B. S. from Michigan State College and M. S. and Ph. D. from the University of Minnesota.

M. F. Elmore of College Park, Maryland, assumed his duties in the Agricultural Extension Service as Associate Extension Dairyman in charge of the dairy herd improvement, management, and feeding project on November 1, 1952. Professor Elmore is a native of Maryland and received his B. S. and M. S. degrees from the University of Maryland. He has completed a major portion of the requirements for his Ph. D. degree.

J. H. Lillard and T. W. Edminister of the Department of Agricultural Engineering, V. P. I., attended a meeting of West Virginia Section, American Society of Agricultural Engineers at Jackson's Mill, West Virginia, on November 7 and 8 and presented papers on the Theory and Design of Supplemental Irrigation Systems and Water Law Problems Related to Irrigation.

V. H. Baker and B. F. Parker of the Department of Agricultural Engineering at V. P. I. are at Michigan State College studying for the Ph. D. degree.

B. L. Parsons, Korean War Veteran, formerly of the Agricultural Engineering Department's teaching staff, returned to his old job in September.

R. L. Givens, U. S. D. A. Agricultural Engineer, is being transferred from the University of Georgia to the Tidewater Experiment Station at Holland, Virginia, where he will continue working on grain storage problems.

S. H. Byrne, Associate Professor in charge of teaching in the V. P. I. Agricultural Engineering Department, returned in September from Iowa State College where he has been studying for his Doctor's degree.

Paul W. Stoneburner, recently resigned as research associate in Agricultural Engineering, Virginia Agricultural Experiment Station, to become sales engineer for Atlantic Aluminum Company.

Denver D. Bragg of the Poultry Department, V. P. I., presented a paper entitled "An Attempt to Determine the Cause of Curled or Deformed Tongues in Young Beltsville White Turkeys" before the 41st annual meeting of the Poultry Science Association at Storrs, Connecticut, in August. Bragg is presenting this work as a thesis in partial fulfillment of the requirements for an M. S. degree. A twenty-eight page illustrated 4-H Poultry and Egg Judging bulletin by Denver D. Bragg was received from the printer in September.—WESLEY P. JUDKINS, *Virginia Polytechnic Institute.*

ASTRONOMY, MATHEMATICS, PHYSICS SECTION

Warren G. Roome, Chairman, Department of Mathematics at Radford College, is on leave studying at Columbia University.

Professor F. D. Rollins, Department of Mathematics, V. P. I., is doing graduate work at Vanderbilt University this year. Mr. V. Ray Hancock has been appointed instructor in the Mathematics Department at V. P. I.

Mr. Jacob L. Rhodes has been appointed Associate Professor of Physics and Acting Head of the Department of Physics and Engineering at Roanoke. He is completing his work for the Ph. D. from the University of Pennsylvania.

Dr. Marguerite Risley, Associate Professor of Mathematics and Astronomy at R. M. W. C., has been awarded a Ford Foundation Fellowship. She is on leave at this time studying at Harvard University. Mr. George S. Mumford III, who holds degrees from Harvard and the University of Indiana, is taking her place.

Mr. C. O. Alley, Jr., former member of the Physics Department at the University of Richmond, has returned to Princeton University to complete his graduate work. He has been replaced by Mr. Arthur E. Williamson, who is a graduate of Alabama Polytechnic Institute and comes to Richmond from North American Aircraft Co.

Harry L. Reaves has joined the faculty of Hampden-Sydney College, as Assistant Professor of Mathematics. He was formerly on the faculty of Clemson College.

Professor G. T. Whyburn, Chairman of the Department of Mathematics at the University of Virginia, is on leave this year. He holds a Faculty Fellowship under the Fund for the Advancement of Education.

Dr. Nicholas Cabrera of the University of Madrid is Visiting Associate Professor of Physics at Rouss Physical Laboratory of the University of Virginia. Dr. Cabrera is a former student of Brillovin and DeBroglie at the University of Paris and of N. F. Mott at the University of Bristol. He is working with Dr. Allen Gwathmey, President-Elect of the Virginia Academy of Science.

Dr. Harold L. Alden, Director of Leander McCormick Observatory of the University of Virginia, was a delegate at the Eighth General Assembly of the International Astronomical Union at Rome. Dr. Alden was elected president of the Commission on Stellar Parallaxes and Proper Motions. In this position he follows in the footsteps of Dr. S. A. Mitchell, Director Emeritus of McCormick Observatory.

The Physics Department at Virginia Military Institute has moved into its new quarters in Mallory Hall. Construction on the new physics laboratory of University of Virginia has been started.—I. G. FOSTER, *Virginia Military Institute.*

BIOLOGY SECTION

Mr. Lee Douglas is a new member of the faculty of Emory and Henry College as Assistant Professor of Biology. Mr. Douglas will be awarded the degree of Doctor of Philosophy by the University of Southern California in June, 1953.

Emory and Henry College has enrolled its first class of candidates for the Bachelor of Science degree in Nursing. The students receive part of their training at The Johnson Memorial Hospital in Abingdon which is affiliated with Emory and Henry College in offering nursing training.

Mr. Julien Cagle is a new member of the Department of Biology at Hollins College. Mr. Cagle received the degree of Master of Arts from the University of Tennessee and was formerly a member of the staff of Cumberland College in Kentucky.

Mr. Paul M. Patterson of Hollins College has been elected to the Governing Board of the American Institute of Biological Sciences. Mr. Patterson represents the American Bryological Society.

Mr. Jack D. Burke is now a member of the biology staff at Longwood College. Mr. Burke was awarded the Doctor of Philosophy degree by the University of Florida. His principle research is in physiology with especial interest in blood volumes.

Madison College announces that construction of its new science build- is well underway and is scheduled for completion by the fall of 1953. The four-story building will house the departments of biology, chem-

istry, physics, geology, and geography. Future plans include wings which will make space available for the department of mathematics.

Miss Peggy Woodson, Instructor in Biology at Randolph-Macon Woman's College, has been granted leave of absence for the current academic year to continue work toward the doctorate. Miss Woodson has been awarded a research fellowship at McGill University to investigate problems dealing with the histology of pulmonary tissues.

Mr. Warwick R. West who received the degree of Doctor of Philosophy from the University of Virginia in June, 1952, and who formerly taught at Lynchburg College, has joined the faculty of the University of Richmond as Assistant Professor of Biology. Mr. West will offer courses in Entomology, Comparative Anatomy, and Embryology.

President Francis P. Gaines of Washington and Lee University recently announced the promotion of Mr. James Holt Starling from Associate Professor to Professor of Biology. Mr. John M. Herr from the University of Virginia has been appointed Instructor in Biology at Washington and Lee.

Mr. George K. Reid, Jr., of the University of Florida has been appointed Assistant Professor of Biology at the College of William and Mary. His chief interest is in animal ecology.

Mr. I. T. Quinn, executive director of the Virginia Game Commission, called together representatives of State and Federal land use agencies to discuss resource-use education in the state. As a result of this conference, a temporary advisory council on conservation education was established with Mr. J. J. Shomon, chairman; Mr. P. H. DeHart, vice-chairman; and Mr. R. R. Bowers, secretary. This temporary council will lead to a permanent organization to educate the public in conservation practices.

The Virginia Fisheries Laboratory, Gloucester Point, Virginia, is presenting a series of television programs to acquaint the public with problems of marine conservation.—ROBERT T. BRUMFIELD, *Longwood College.*

CHEMISTRY SECTION

Dr. Harry J. Kiefer has resigned his position as Head of the Chemistry Department at Hampden-Sydney College and has joined the research staff of the Glidden Company in Cleveland, Ohio. Dr. T. H. Pearson, formerly Assistant Professor of Chemistry at the Virginia Military Institute, has taken over Dr. Kiefer's duties at Hampden-Sydney.

Harriett H. Fillinger, Hollins College, published in August a laboratory manual of temporary instructions entitled "*Chromatographic Analysis for the Metal Ions of a First Course in Qualitative Analysis*". Funds to publish the manual and to provide for its distribution to a number of colleges and universities to check the analytical methods were made available through a grant from the Hollins College Research Fund. Miss Fillinger also published (with Lois Ann Trafton) a paper on the "Chromatographic Analysis of Metal Ions" in the June, 1952, issue of the *J. Chem. Educ.* and presented a paper on the same topic at the September meeting of the American Chemical Society in Atlantic City.

Dr. Elizabeth H. Burkey, Hollins College, was elected Secretary of the Virginia Blue Ridge Section of the American Chemical Society, and

H. H. Fillinger, who was Chairman of the Blue Ridge Section last year, is a new member of the Executive Committee (Council) of the Section this year.

Two graduates of Hollins College, Jean Marshall ('50) and Suzanne Peter ('51) hold positions as editorial assistants at the national headquarters of the American Chemical Society in Washington, D. C., and Lois Ann Trafton ('50) is a research assistant in the Department of Pharmacology at the University of Virginia. Miss Patricia Lewis Paynter ('51) is employed as a microanalyst in the Chemistry Department of the University of Virginia, and Miss Jane Kelly ('51) is working with Rodney C. Berry, State Chemist, in Richmond.

Dr. R. D. Cool, Professor of Chemistry at Madison College, attended the summer conference of the New England Association of Chemistry Teachers held at the University of Vermont in August. Also present at the meeting was Miss Caroline R. Gambrill of Fairfax Hall Junior College, Waynesboro.

Members of the 1952 graduating class at Madison College who have accepted positions in chemistry include: Mary Ellen Orr, Janet Lee Shelor, and Bette Jane Viar, now with du Pont at Martinsville; Charlotte Celia Korn with Dr. J. C. Forbes at the Medical College of Virginia; and Lawrence E. Paxton who has accepted a U. S. Civil Service appointment. Marianna Virginia Howard and Barbara Ann Groseclose, both former Madison students, are among the new chemistry teachers in the State. Miss Howard is located in Danville and Miss Groseclose in Wythe County.

Recent publications from the Medical College of Virginia: "Studies On The Effects of Metallic Salts on Acid Production of Saliva. *I.*", J. C. Forbes and J. D. Smith, *Journal of Dental Research*, 31, 129 (1952). "Metabolic Studies in Pernicious Anemia. I. Nitrogen and Phosphorus Metabolism During Vitamin B_{12}-Induced Remission," G. Watson James, III and Lynn D. Abbott, Jr., *Metabolism, 1*, 259 (1952).

Dr. J. C. Forbes, Professor of Research Biochemistry, and Mrs. Geraldine M. Duncan, Research Assistant, Medical College of Virginia, presented a paper on the "Effect of Alcohol Intoxication on the Cholesterol and Ascorbic Acid Content of Guinea Pig Adrenal Glands" at the April meeting of the American Society of Biological Chemists in New York City.

Dr. Lynn D. Abbott, Associate Professor of Biochemistry, Medical College of Virginia, was among a group of 42 research workers throughout the country who enrolled in an advanced course in radioisotope techniques offered in November by the Oak Ridge Institute of Nuclear Studies. Dr. Abbott is conducting investigations concerned with mechanisms influencing blood formation and destruction.

Publications by staff members of Randolph-Macon Woman's College include the following articles: "Acylation Studies. I. Methyl Cyclopropyl Ketone", George W. Cannon and Helen L. Whidden (R-MWC), *Journal of Organic Chemistry*, 17 (1952); "The Solubilities of Benzene, Nitrobenzene, and Ethylene Chloride in Aqueous Salt Solutions", J. H. Saylor, A. I. Whitten, Imogene Claiborne (R-MWC), and P. M. Gross, *Journal of the American Chemical Society*, 74, 1778 (1952); and "Dissociation Constants of Adrenergic Amines", Esther B. Leffer (R-MWC), Hugh M. Spencer, and Alfred Burger, *ibid.*, 73, 2611 (1951).

Miss Katherine Wright, Professor at American College, Istanbul, Turkey since 1931, has joined the staff at Sweet Briar College.

Dr. Dorothy D. Thompson has returned to Sweet Briar from sabbatical leave at the Institute of Textile Technology in Charlottesville. The results of her research at ITT, carried out with Jack Compton, C. P. Jones, and D. R. Roberts, were reported by Dr. Compton at the Southeastern meeting of the American Chemical Society held at Auburn, Alabama in October. The paper was entitled, "The Effect of Partial Cyanoethylation and Acetylation on Certain Measurable Properties of Cotton Fiber".

Miss Anne Pitts and Miss Jane Maxwell, both of Sweet Briar College, are continuing studies for their doctorate degrees, the former at Duke and the latter at Emory University.

W. Allan Powell has been appointed Assistant Professor of Analytical Chemistry at the University of Richmond, replacing Roger Buck, who is now associated with the Virginia Institute for Scientific Research. Mr. Powell has completed work for his doctorate at Duke University and plans to receive his degree in June.

Publications from the University of Richmond: "2-Methyl-2-monoalkylaminopropyl Aromatic Heterocylic Carboxylates", J. Stanton Pierce and Henry A. Rutter, Jr., *Journal of the American Chemical Society*, 74, 3954 (1952); and "N-Aryl-N'-alkyloxamides for the Identification of Primary Alkyl Amines", A. G. Richardson, J. Stanton Pierce, and E. Emmet Reid, *ibid.*, 74, 4011 (1952).

The Research Corporation has awarded a grant to the University of Richmond to support an investigation of coordination complexes. The project will be under the direction of Dr. W. E. Trout and Dr. J. Stanton Pierce.

Dr. Thomas C. Franklin, Assistant Professor of Physical Chemistry at the University of Richmond, has also been awarded a grant from the Research Corporation to conduct polarographic studies of oxidation at the platinum electrode. He will be assisted in the work by R. D. Sothern.

Professor Raymond N. Castle of the University of New Mexico is spending a sabbatical leave of one year at the University of Virginia working with Dr. Alfred Burger on an American Tobacco Company post-doctoral fellowship.

Recent promotions of the chemistry faculty at the University of Virginia include Dr. Alfred Burger, Professor, Dr. Allan T. Gwathmey, Associate Professor, and Dr. Paul M. Gross, Assistant Professor. Mr. Carl D. Lunsford has received a one-year appointment as Instructor for teaching and research.

Dr. Nicholas Cabrera, formerly of the Bureau International des Poids et Mesures in Paris, is now an Acting Associate Professor of Physics at the University of Virginia. Part of his time will be devoted to research on the surface properties of metal crystals, studies being carried out in the Chemistry Department supported by the Office of Naval Research and directed by Dr. Allan T. Gwathmey.

Also on post-doctoral Office of Naval Research Fellowships are Dr. Fred W. Young and Dr. Kenneth R. Lawless, both recent graduates of the University, the former after a year at the Oak Ridge National Laboratory and the latter after a year in Norway on a Fulbright Fellowship.

Additional fellowship awards in chemistry at the University of Virginia are as follows:

Mr. Colin L. Browne has been awarded a fellowship by the National Science Foundation for research on ring-chain tautomerism under the direction of Dr. Robert E. Lutz.

Mr. Robert Darby is the recipient of a U. S. Public Health Service Fellowship for work on analogs of thyroxine under the direction of Dr. Alfred Burger.

Dr. R. E. Lutz has received a two-year grant from the Eli Lilly Company to support the research of Mr. Claibourne E. Griffin on compounds of possible medicinal value.

Mr. Edwin D. Hornbaker has been appointed Parke, Davis and Company Fellow. He will investigate potential tuberculous drugs.

The Virginia-Carolina Chemical Corporation is sponsoring two pre-doctoral fellowships under the direction of Dr. Alfred Burger. The Fellows, Miss Beverly E. Smith and Mr. Thomas Hilton, are working on organic compounds of phosphorus which are of biological interest.

Additional fellowships awarded to the Chemistry Department for predoctoral education include: The Merck Company Fellowship, held by Mr. Richard M. Rush; the du Pont Company Post-graduate Fellowship in Chemistry, held by Mr. Peter B. Sherry; and the Texas Company Fellowship held by Mr. James B. Wagner.

Dr. Allan T. Gwathmey of the University of Virginia staff received the Southern Chemists Award from the Memphis Section of the American Chemical Society for his work in the study of metal catalysis and for his leadership in the establishment of the Virginia Institute for Scientific Research. The award is given "for distinguished service to the profession of chemistry in the southern states" and was presented at the Southeastern Regional Meeting of the Society held in October at Auburn, Alabama.

Dr. John H. Yoe, Professor of Chemistry and Director of the Pratt Trace Analysis Laboratory, attended the International Congress on Analytical Chemistry at Oxford, September 4-9, 1952, and meetings of the International Committee on Analytical Reactions, also at Oxford, September 3 and 10. While in Europe, he visited the Macaulay Institute for Soil Research at Aberdeen, Scotland and the University of St. Andrews, Scotland.

Dr. Russell J. Rowlett, Dr. D. Scott Sears, and Earl B. Whipple joined the Virginia-Carolina Chemical Corporation Research Department as of July 1, 1952. Dr. Rowlett comes from Chemical Abstracts as patent coordinator; Dr. Sears from Goodrich Rubber as inorganic group leader; and Mr. Whipple as an organic chemist from graduate work at Harvard University.

Mrs. Frances Cook, formerly research physicist for General Mills at Minneapolis, has joined the staff of the Virginia Institute for Scientific Research.

Dr. Thomas C. Franklin and Mr. George P. Williams, both members of the University of Richmond Faculty, are serving as part-time staff members of the Virginia Institute for Scientific Research. Ballard Pierce, an undergraduate at the University of Richmond, is also assisting with studies using the electron microscope.

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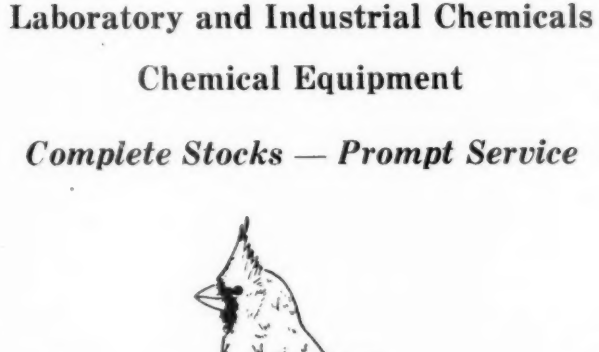

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Staff notes from the Virginia Military Institute: Assistant Professor B. W. Mundy has been promoted to Associate Professor of Physical Chemistry. Assistant Professor G. Wise has returned from service in the Navy, and Assistant Professor G. M. Pickral has returned from leave, granted for the purpose of pursuing graduate studies.

Dr. C. W. Smart of the V. M. I. staff has a publication (with H. R. Henze and W. J. Clegy) in the October issue of the *Journal of Organic Chemistry* entitled "Certain Derivatives of 2-Methyl Pyrimidine".

Another entire floor of Richardson Hall at the Virginia Military Institute has been converted to the use of the Chemistry Department. Two new laboratories devoted to qualitative and quantitative analysis have been completed and are now being used. A special invitation is extended to all V.A.S. members to inspect the facilities of the chemistry department at the annual meeting in May. All classrooms and laboratories will be open.

Dr. R. E. Hussey, Professor of Organic Chemistry, and a member of the staff at Virginia Polytechnic Institute since 1926, retired July 1, 1952.

Mr. W. B. Howsmon, Jr., a graduate of Berea College and Purdue University, has joined the staff at V.P.I. as an Instructor in Chemistry.

V. P. I. publications: "The Synthesis and Cyclization of Some *o*-Benzylphenones", F. A. Vingiello, J. G. Van Oot, and H. H. Hannabas, *Journal of the American Chemical Society,* 74, 4546 (1952); "A Study of the Shape Factor for High Polymers", by P. C. Scherer and J. E. Johnson, to appear shortly in *Modern Textiles.*

Dr. F. A. Vingiello, Associate Professor of Chemistry at V. P. I., has been awarded a contract by the Office of Ordnance Research for work on the synthesis of hydrocarbons. Two research assistants are working with Dr. Vingiello on the problem. Work on the project began October 1.

Dr. J. W. Watson, Head of the Chemistry Department at Virginia Polytechnic Institute and Councilor for the Virginia Blue Ridge Section of the American Chemical Society, attended the September meeting of the Society held in Atlantic City. As an invited guest, Dr. Watson also attended in September the dedication of Proctor and Gamble's new research laboratories located near Cincinnati, Ohio.

Dr. Frank A. Vingiello was a research participant during the summer at the Oak Ridge National Laboratory. With O. L. Neville he worked on the mechanism of the benzil-benzilic acid rearrangement using radioactive C^{14} as a tracer.

Dr. Robert C. Krug, also of the V. P. I. staff, was affiliated with the Virginia Institute for Scientific Research during July and August as a research chemist investigating some of the factors which are believed to influence the growth of large single crystals of certain metals.

Dr. E. F. Furtsch and Professor E. V. Russell worked during the summer on a research problem with the V. P. I. Engineering Experiment Station.

Dr. John F. Baxter has resigned as Professor of Chemistry at Washington and Lee University and is now located at the University of Florida.

Dr. E. S. Gilreath has been promoted from Assistant to Associate Professor at W. and L., and Dr. Elmer S. McKee has been added to the staff as an Assistant Professor of Chemistry.

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McGraw-Hill has announced the publication (in November) of a second edition of Dr. Lucius J. Desha's well-known text on *"Organic Chemistry"*. Among the major changes in the new edition are the introduction of the concept of resonance and the electronic explanation of reaction mechanisms.

C. H. Rayburn will present a paper entitled "Determination of Some Volatile Phenols in Cigarette Smoke" at the Annual Tobacco Chemists Research Conference, which this year will be held at the University of Louisville, Louisville, Kentucky, December 4 and 5. J. M. Moseley, also of the research staff of The American Tobacco Company, will participate in a panel on "Analytical Methods."—CARL J. LIKES, *Virginia Institute for Scientific Research.*

EDUCATION SECTION

Preliminary Findings of the Committee On Science Teaching in Virginia Schools

A Committee on Science Teaching in Virginia Schools was created by the Academy late in 1951. The Committee consists of:

Dr. F. G. Lankford, Jr., (Chairman), Department of Education, University of Virginia

Dr. Byron M. Cooper, Department of Geology, Virginia Polytechnic Institute

Mr. John B. Chase, Jr., Department of Education, University of Virginia

Dr. George Jeffers, Head of the Department of Biology, Longwood College

Dr. James W. Cole, Department of Chemistry, University of Virginia

Dr. Percy H. Warren, Madison College

Dr. William M. Hinton, Professor of Psychology, Washington and Lee University

Mr. F. D. Kizer, Science Faculty of Norview High School

Dr. R. O. Nelson, Superintendent of Schools, Newport News, Virginia

Mr. Paul H. Cale, Superintendent of Schools, Albemarle County, Charlottesville

Currently the Committee has under way three studies.

One of these is being done by Professor Percy Warren and deals with science offerings in Virginia high schools, teacher assignments, and teacher preparation.

Among the preliminary findings are these:

> "It was found that more than 50 per cent of the high schools in Virginia have a minimum science offering of general science, biology, and chemistry. Nothwithstanding this fact, more than 50 per cent of the teachers who taught one or more classes in science taught only one or two science classes. More than 60 per cent taught only one science subject and more than 85 per cent of the teachers taught no more than two different subjects in science."

Professor Warren's data on preparation of teachers is now being tabulated. Mr. John B. Chase is studying for the committee the certification of science teachers. He is studying practices in Virginia as well as other states. He has also asked Virginia superintendents several questions regarding their practices and opinions. From this latter source he reaches the tentative conclusion (1) that superintendents feel that their high school science positions call for teachers who are certified to teach general science in combination with biology, with chemistry, or with physics, and (2) that superintendents feel that science teachers should have background in all phases of science and should be certified to teach more than one science.

Also, his preliminary findings indicate that there are 22 states with certification requirements in science comparable to, or higher than, those now existing in Virginia.

A third study from which the Committee may draw useful information is the Masters thesis compleetd by Mr. Philip Peterson at the University of Virginia. He studied science offerings and elections in Virginia high schools. Among his several findings this one on elections will be of great interest to the Committee. The most frequent combination of science elections by pupils in Virginia high schools is one unit in general science and one unit in biology (36%). The second most frequent combination of elections is one course in general science with one in biology and one in chemistry (19%). Only 6% of the high school pupils elect all four sciences including general science, biology, chemistry ,and physics.

—F. C. LANKFORD, *University of Virginia.*

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PSYCHOLOGY SECTION

An unusually large number of Virginia psychologists took advantage of the nearby convention of the American Psychological Association in September by attending the meetings in Washington. Dr. Gilbert J. Rich is the Chairman of the Committee on Scientific and Professional Ethics of the A. P. A. Mr. Frank A. Geldard, retiring President of the Division of Military Psychology, was appointed to the Education and Training Board of the A. P. A. Mr. William M. Hinton represented the Psychology Section at the conference of State Psychological Associations which was held during the A. P. A. meetings.

Mr. John N. Buck has resigned from the Examining Board for the Certification of Clinical Psychologists, having been succeeded in the chairmanship of that board by Mr. Hinton. Dr. Gilbert R. Rich is the new member of this board.

Mr. Henry A. Imus has completed a year's service as Scientific Liaison Officer in the field of Psychology, London Branch of the Office of Naval Research, and has returned to his duties as Head of the Physiological Psychology Branch, Psychological Sciences Division, Office of Naval Research in Washington. While he was in England, Mr. Imus was elected a fellow in the Royal Society of Medicine, a member of the Ergonomics Research Society, a member of the British Psychological Society, and a visiting foreign member of the Experimental Psychology group.

Mr. Jason Z. Edelstein has joined the Department of Psychology of the Eastern State Hospital as assistant psychologist. Mr. Edelstein received his M. A. degree from the University of New Hampshire and took his psychological internship at Danvers State Hospital, Massachusetts. The psychology department at Eastern State Hospital now consists of three psychologists, headed by Mr. David Orr as senior psychologist. The third staff member is Mrs. Elizabeth Williams, assistant psychologist. Mr. Orr is also a part-time lecturer in psychology at the College of William and Mary.

Miss Hannah Davis has been appointed chief psychologist to succeed Mr. John N. Buck at the Lynchburg State Colony.

Mr. John F. Hahn has assumed his duties as Acting Assistant Professor of Psychology at the University of Virginia. Mr. Hahn received his doctoral training at the University of Chicago, having done some of his graduate work with Professor L. L. Thurstone and having worked under the immediate direction of Professor Dewey Neff. Mr. Hahn succeeds Mr. Willard R. Thurlow, who took a position at the University of Wisconsin in February, 1952.

Mr. Frank W. Finger was a visiting member of the summer school staff at the University of Wisconsin. Visiting professors on the University of Virginia summer school staff were Mr. William M. Hinton, Mr. Robert C. Wingfield of Converse College, and Mr. John F. Hall of Pennsylvania State College.—RICHARD H. HENNEMAN, *University of Virginia.*

STATISTICS SECTION

M. E. Terry, formerly of the Department of Statistics and Statistical Laboratory, Virginia Polytechnic Institute, has joined the staff of the Bell Telephone Laboratories at Murray Hill, New Jersey. Dr. Terry served for

three years as secretary of the Statistics Section, and his departure is a great loss to the Academy and to the State.

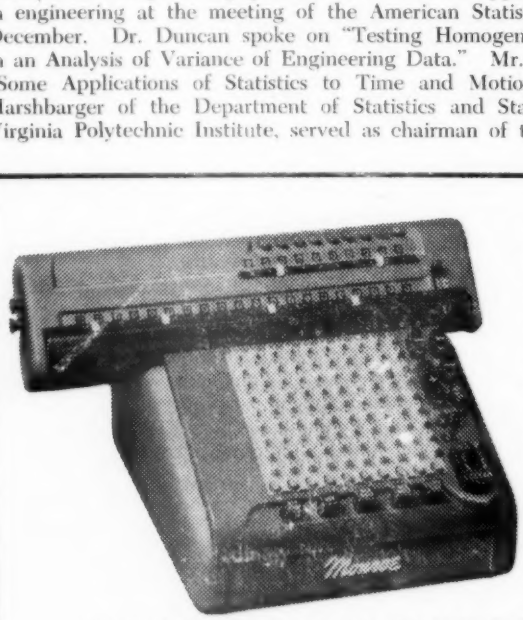
M. C. K. Tweedie, a graduate of University of Reading, England, and recently of Oxford, has joined the staff of the Department of Statistics and Statistical Laboratory of the Virginia Polytechnic Institute. His publications include "Inverse Statistical Variates," "The Regression of the Sample Variance on the Sample Mean," and "Functions of a Variate with Given Means, with Special Reference to Laplacian Distributions."

Lionel Weiss, formerly of the University of Virginia, has now joined the staff at Cornell University.

W. J. Youden, National Bureau of Standards, presented a paper on "Linked Blocks" at the session on Experimental Design at the Joint session of the American Statistical Association and Biometrics Society meeting in Chicago in December.

W. J. Youden and Churchill Eisenhart, both of the National Bureau of Standards, presented a paper on "Comparison of Standard Meter Bars" at the session on Application of Statistics to Physics at the meetings of the American Statistical Association in December.

D. B. Duncan and H. C. Sweeny of the Virginia Polytechnic Institute were invited to present papers at the session on applications of statistics in engineering at the meeting of the American Statistical Association in December. Dr. Duncan spoke on "Testing Homogeneity of Treatments in an Analysis of Variance of Engineering Data." Mr. Sweeny's title was "Some Applications of Statistics to Time and Motion Research." Boyd Harshbarger of the Department of Statistics and Statistical Laboratory, Virginia Polytechnic Institute, served as chairman of this session.



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M. E. Terry, now of the Bell Telephone Laboratories, presented a paper on "Rank Analysis in the Estimation of Threshold Values" at the session on Applications of Non-Parametric Methods at the Chicago meetings of the A. S. A. and Biometric Society.

At the joint meetings of the American Statistical Association and the Institute of Mathematical Statistics held in Chicago in December, M. C. K. Tweedie presented two papers. These are entitled "Bias in Estimation by Interval" and "The Covariances of Frequencies from a Multinomial Distribtuion under a Sequential Sampling Rule." R. A. Bradley of the Department of Statistics and Statistical Laboratory, Virginia Polytechnic Institute, presented an invited paper on "Non-Parametric Methods in the Elementary Statistics Course."

"New Designs and Techniques of Organoleptic Testing" by M. E. Terry, R. A. Bradley and L. L. Davis was published in the July issue of *Food Technology*. "The Rank Analysis of Incomplete Block Designs I — The Method of Paired Comparisons" by R. A. Bradley and M. E. Terry was published in the December issue of *Biometrika*.

The contract between the Department of Statistics and Statistical Laboratory, Virginia Polytechnic Institute, and the Bureau of Agricultural Economics for studies in subjective testing has been renewed for an additional two years. The research on this project has been under the direction of R. A. Bradley. Recently a contract for the computation of tables for the rank analysis of incomplete block designs has been awarded to the Department of Statistics by the Quartermaster Corps, U. S. Army. D. B. Duncan is chief investigator of a research contract on "Statistical Inference Problems Concerning Differences Between Ranked Treatments in an Analysis of Variance" recently awarded to the Department of Statistics by the Ordnance Corps. Work has been completed on a computational contract between the American Meat Institute Foundation and Department of Statistics and Statistical Laboratory. C. Y. Kramer has directed the computations on this project.

Twenty-four graduate students registered this fall for masters and doctors degrees in Statistics at the Virginia Polytechnic Institute. Among these are six who hold fellowships. Ronald E. Schneider and Patricia Ann Ripley hold fellowships with the National Institute of Health. Thomas S. Russell and Paul G. Sanders hold teaching fellowships. William Beyer, Richard G. Cornell, and Daniel Zakich hold research fellowships with the Virginia Agricultural Experiment Station.

Richard P. Bartlett has joined the staff of the United States Department of Agriculture as Statistical Agent at Raleigh, North Carolina.

R. A. Bradley presented an invited paper on "Statistical Methods in Taste Testing and Quality Evaluation" to the Joint Symposium of the Biometric Society and the American Society of Horticultural Science at Cornell University. He also presented a series of lectures on subjective testing to staff members of the Bureau of Agricultural Economics in Washington, D. C. and at Beltsville, Maryland.

Those desiring to present papers at the May meetings of the Academy should present abstracts to the Secretary of the Statistics Section at the earliest possible date.—C. Y. KRAMER, *Virginia Polytechnic Institute*.

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